
Impacts, Risks, and Adaptation in a Changing Climate: An Overview of the Fourth National Climate Assessment

Benjamin DeAngelo
*Deputy Director, Climate Program Office
NOAA Oceanic & Atmospheric Research*

18 June 2019



U.S. Global Change
Research Program

Legislative mandate: U.S. Global Change Research Program

- USGCRP began as a Presidential initiative in 1989
- Mandated by Congress in the U.S. Global Change Research Act (GCRA) of 1990 “to assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change”
- Overseen by Principals representing the 13 member agencies of the Committee on Environment’s Subcommittee on Global Change Research (SGCR)



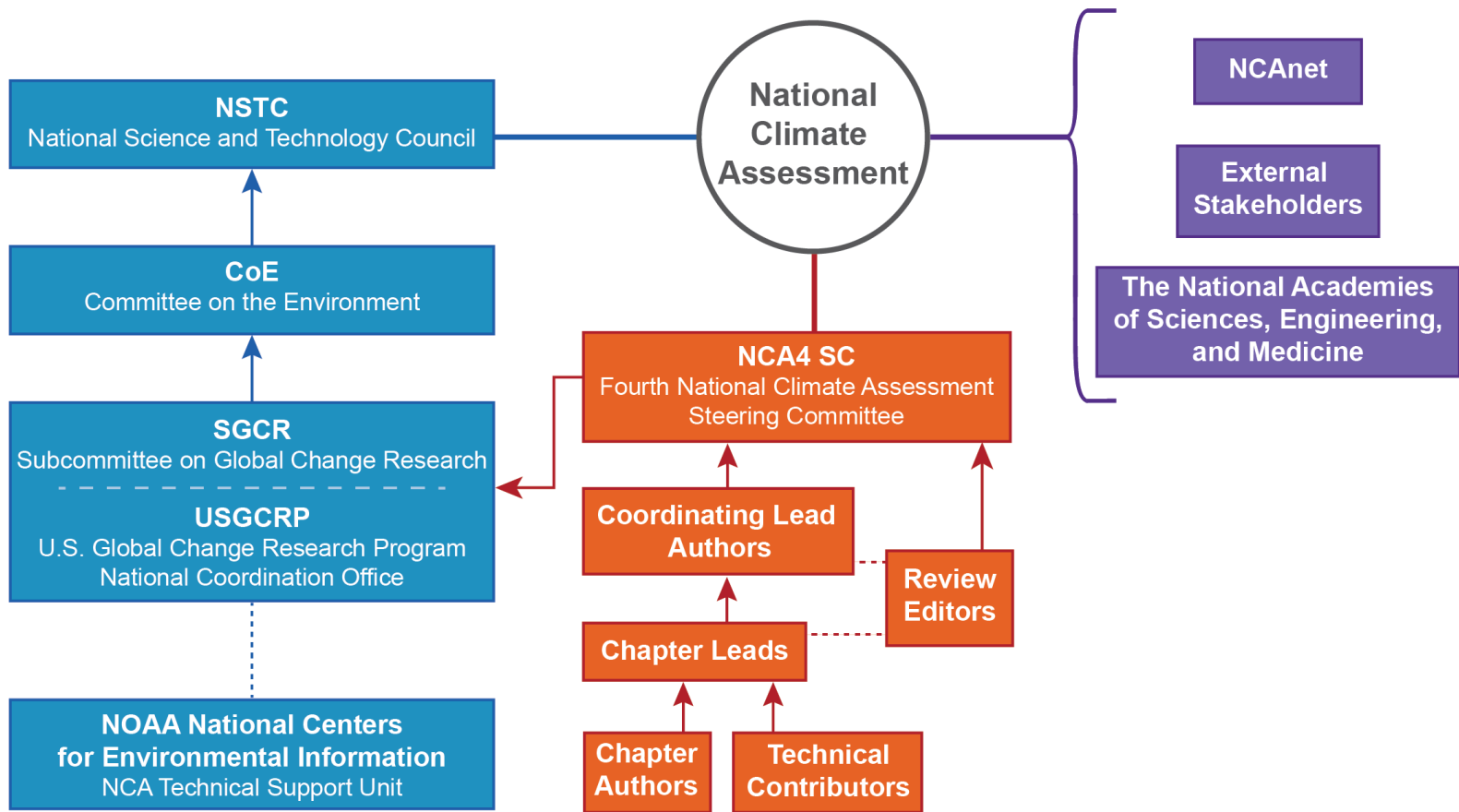
Legislative mandate for a quadrennial NCA

Global Change Research Act of 1990, Section 106:

Not less frequently than every 4 years [USGCRP] shall prepare and submit to the President and Congress an assessment which:

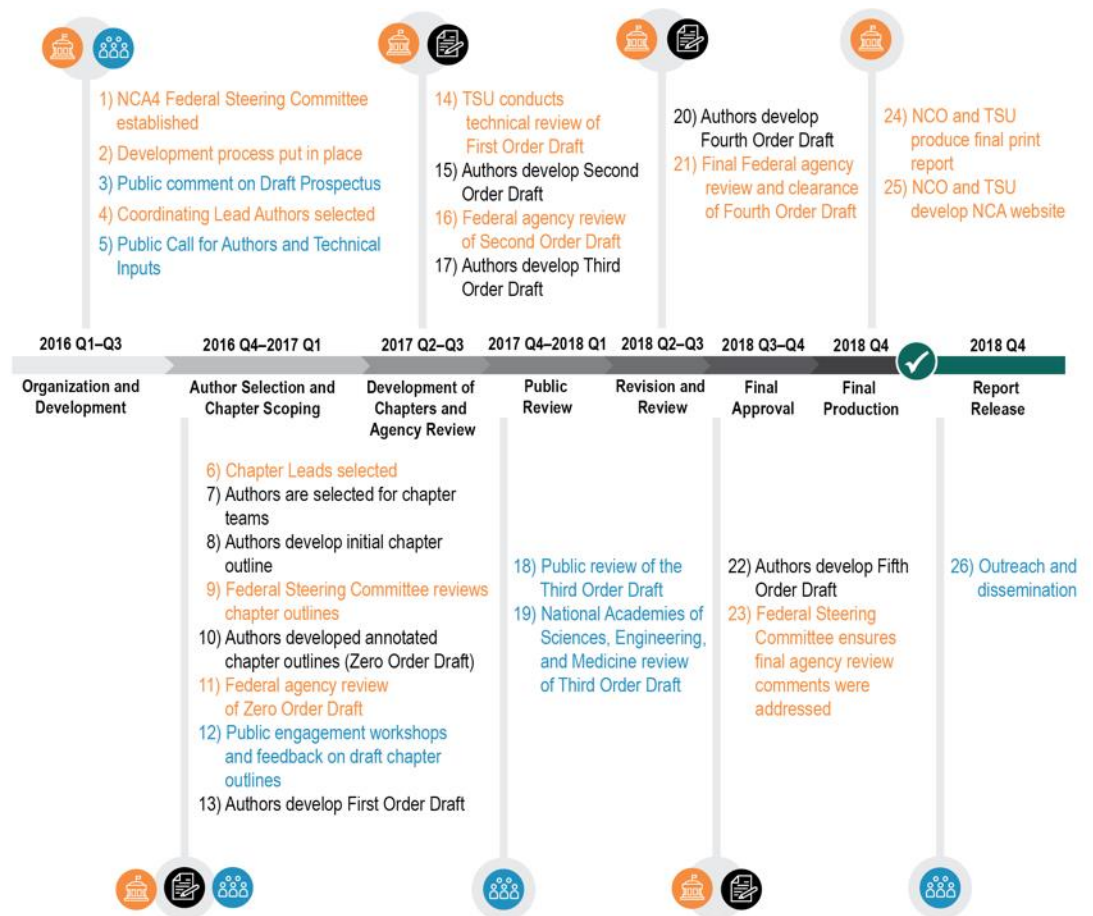
- Integrates, evaluates, and interprets the findings of [USGCRP] and discusses the scientific uncertainties associated with such findings
- Analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity
- Analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.





Report development process

- Multiple points of **federal review and decision** (*orange icons*) were present throughout the process.
- In addition, **public engagement** (*blue icons*) was a cornerstone of the NCA4 development process.
- Authors used these feedback mechanisms to inform their **chapter's development** (*black icons*).



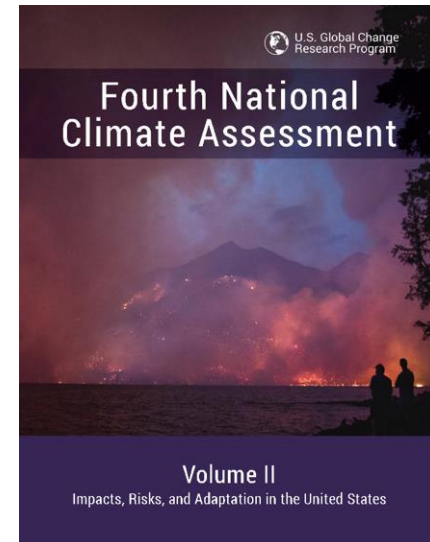
NCA4: a two-volume effort

Congressional Mandate	Fourth National Climate Assessment (NCA4)	
	Vol I: Climate Science Special Report	Vol II: Impacts, Risks, and Adaptation in the U.S.
Integrates, evaluates, and interprets the findings of the Program (USGCRP) and discusses the scientific uncertainties associated with such findings	✓	✓
Analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity	✓	✓
Analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.	✓	✓



NCA4 Vol II: *Impacts, Risks, & Adaptation in the United States*

- Released Nov 23, 2018
- **Policy relevant**, but not policy prescriptive
- Places a strong emphasis on **regional information**
- Quantifies some **impacts in economic** terms
- Integrates **international** considerations
- Assesses a **range of potential impacts**, helping decision makers better identify risks that could be avoided or reduced
- Uses **case studies** to provide additional context and to showcase community success stories



Read and download the report at
nca2018.globalchange.gov

Table of Contents

I. Overview

II. Our Changing Climate

III. National Topics

- Water
- Energy Supply, Delivery and Demand
- Land Cover and Land-Use Change
- Forests
- Ecosystems, Ecosystem Services, and Biodiversity
- Coastal Effects
- Oceans and Marine Resources
- Agriculture and Rural Communities
- Built Environment, Urban

Systems, and Cities

- Transportation
- **Air Quality**
- Human Health
- Tribes and Indigenous Peoples
- **Climate Effects on U.S. International Interests**
- **Sector Interactions, Multiple Stressors, and Complex Systems**

IV. Regional Chapters

- Northeast
- Southeast
- **U.S. Caribbean**
- Midwest
- **Northern Great Plains**

• **Southern Great Plains**

- Northwest
- Southwest
- Alaska
- Hawai`i and U.S.-Affiliated Pacific Islands

V. Response

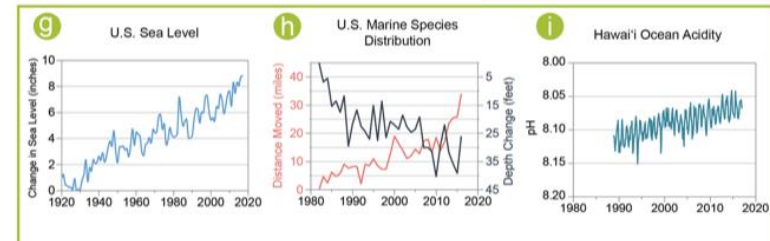
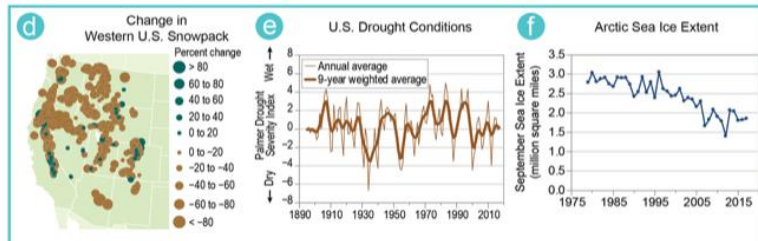
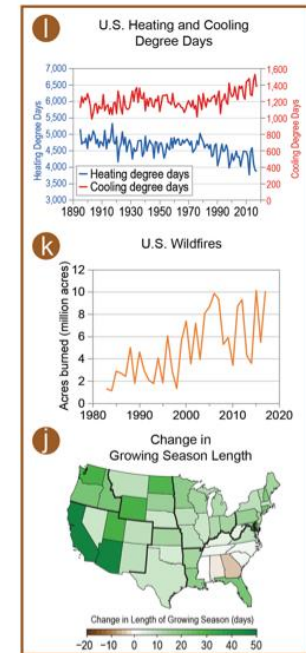
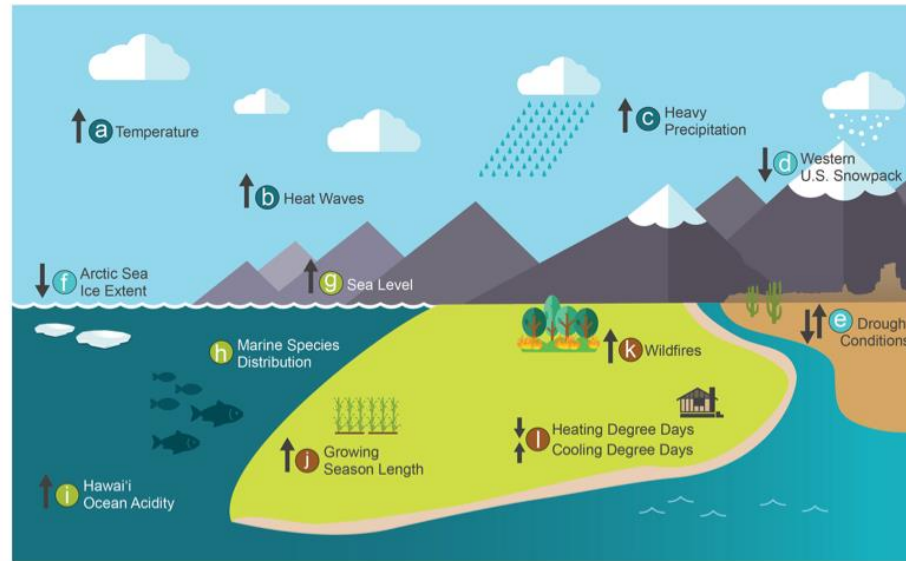
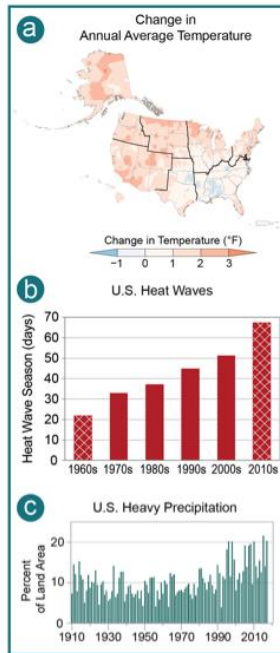
- Reducing Risks Through Adaptation Actions
- Reducing Risks Through Emissions Mitigation

VI. Appendices

- Process
- Information Quality Act
- Data Tools and Scenarios
- **International**
- Frequently Asked Questions

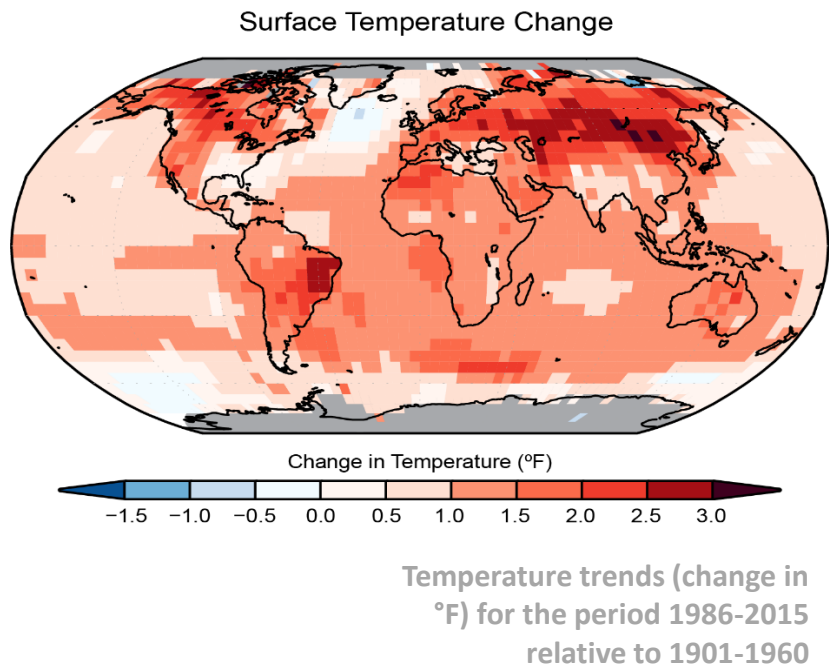


Observed Change

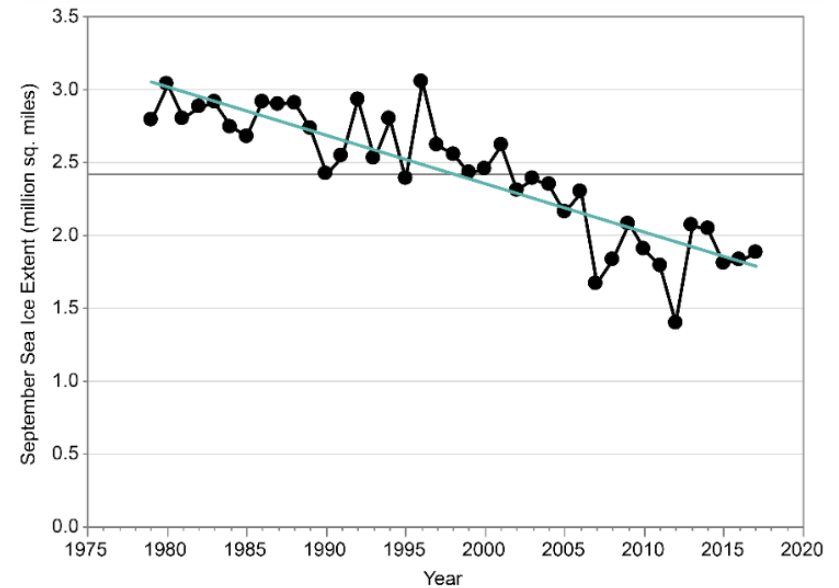
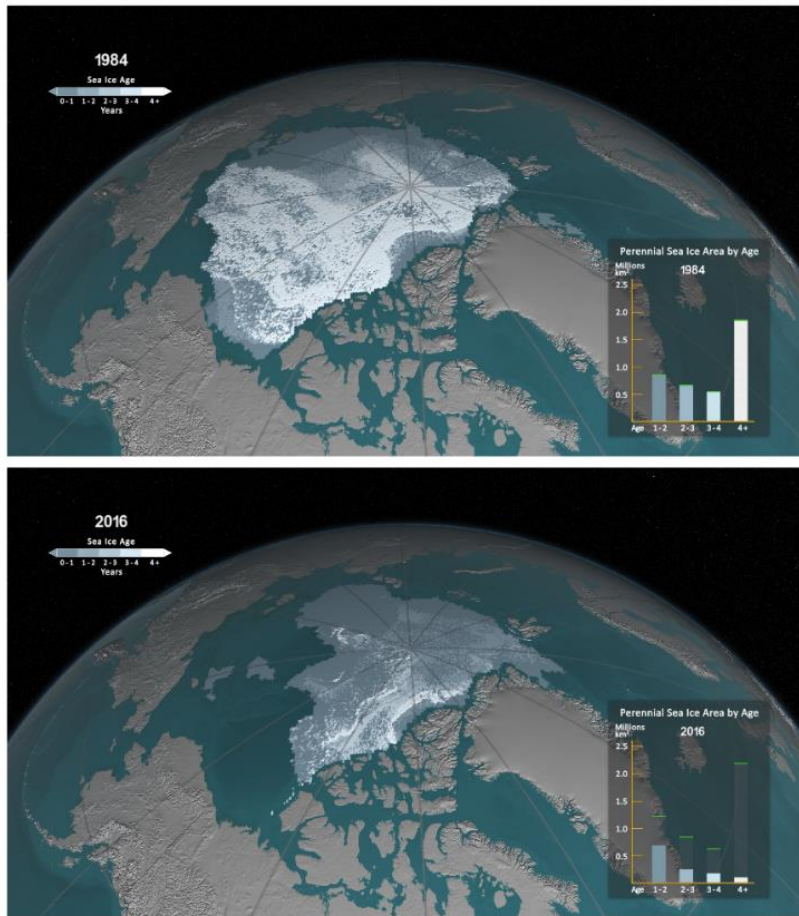


Temperatures globally continue to change rapidly

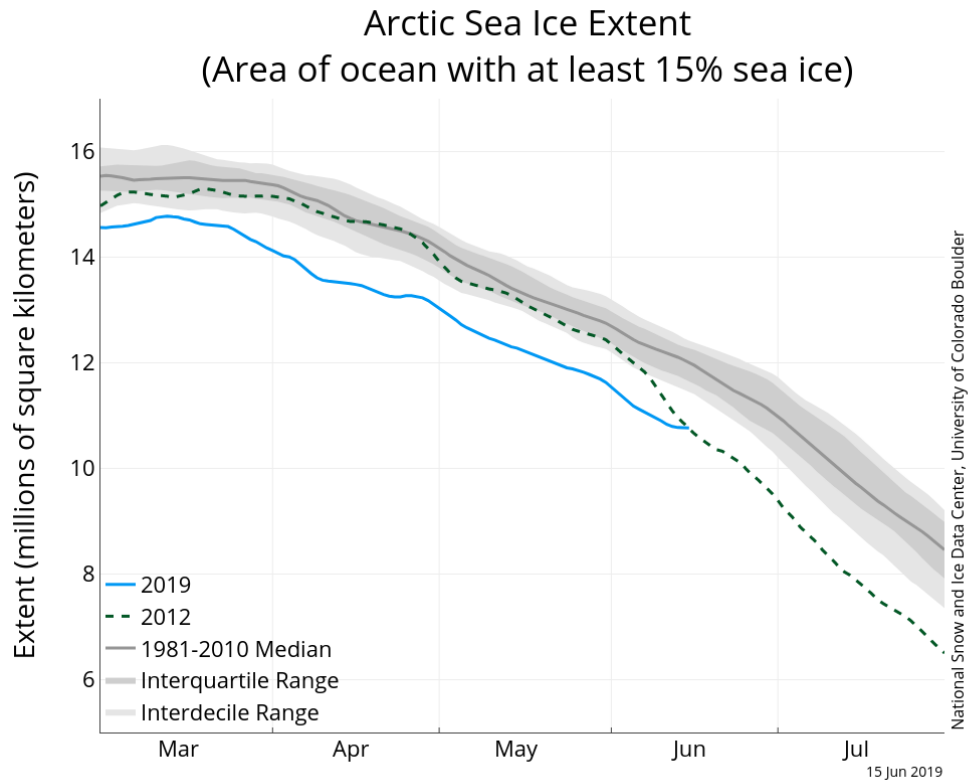
- Since NCA3 was published, the global, long-term, and unambiguous warming trend has continued
- 2016 was the warmest year on record, 2015 is 2nd and far surpassed 2014, which is 3rd
- Since 2000, 16 of the 17 years warmest years on record have occurred
- Global average temperature has increased by about 1.8°F from 1901 to 2016



Diminishing Arctic sea ice



Diminishing Arctic sea ice



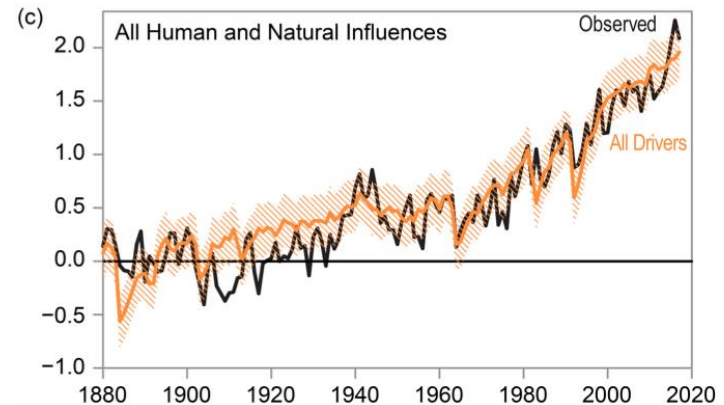
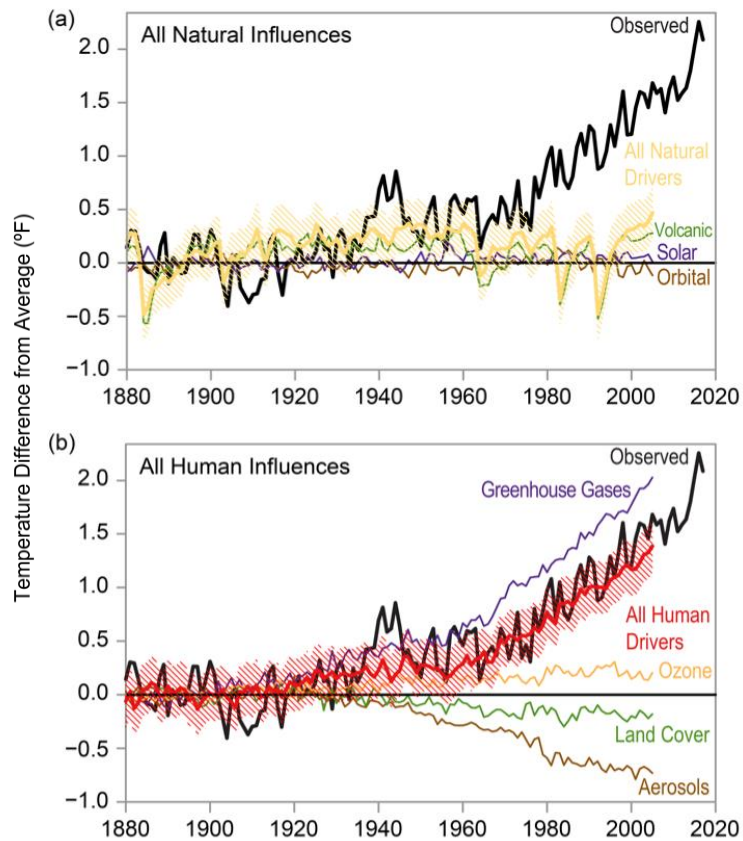
Steffen Olsen, an Arctic researcher with the Danish Meteorological Institute, and dogs set out to retrieve oceanographic moorings and a weather station over meltwater topping sea ice in northwest Greenland on Thursday. (Steffen Olsen)

By [Jason Samenow](#)
June 14

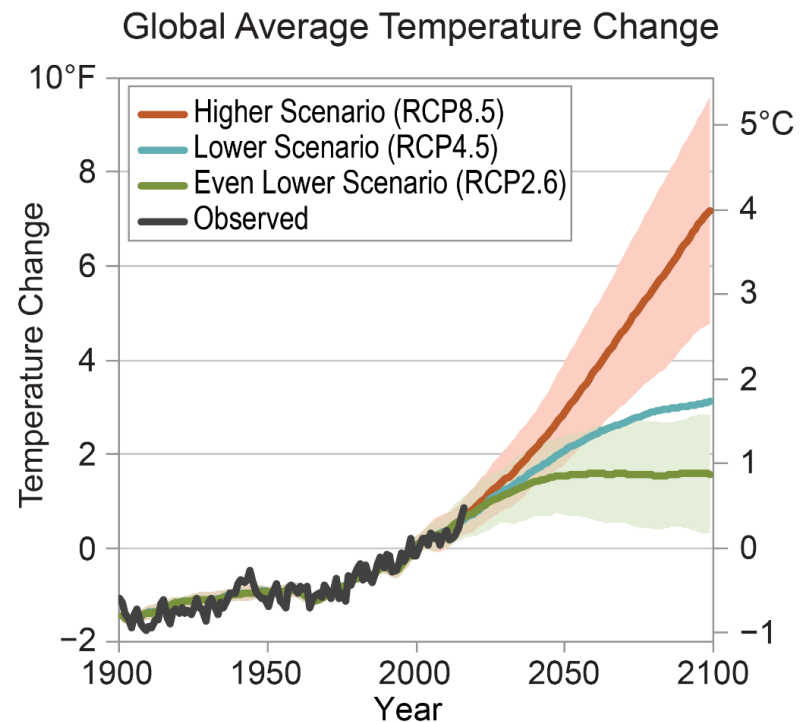
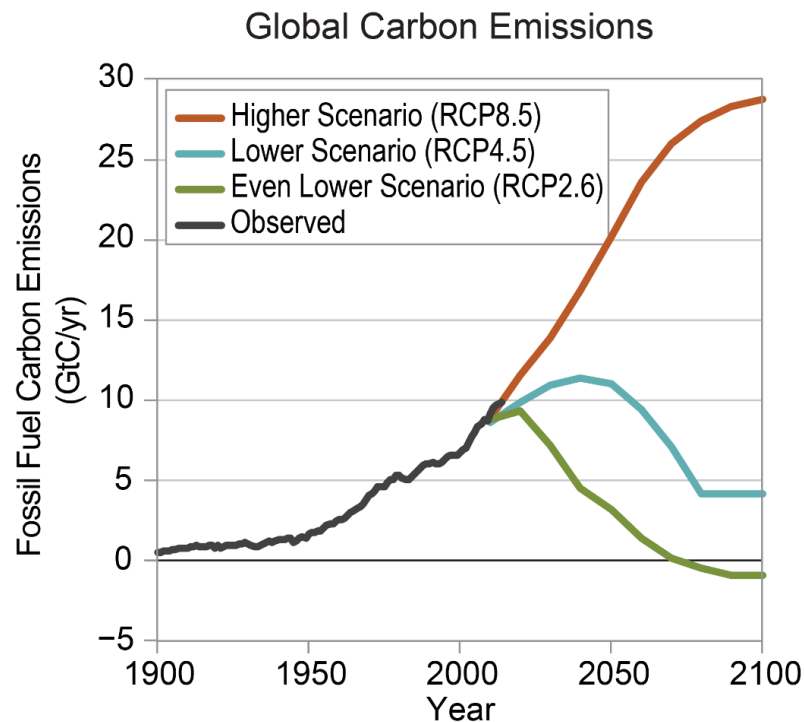


U.S. Global Change
Research Program

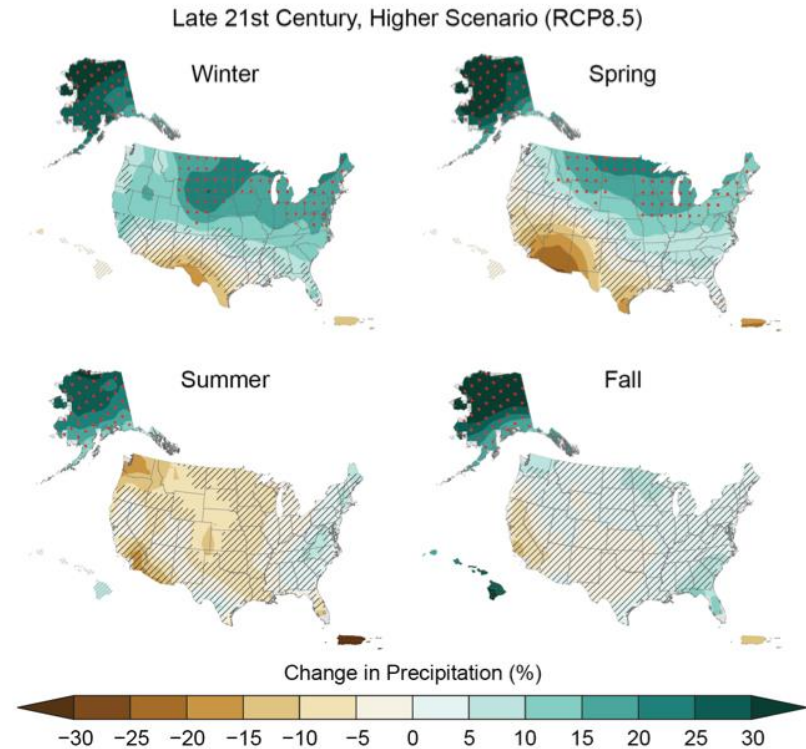
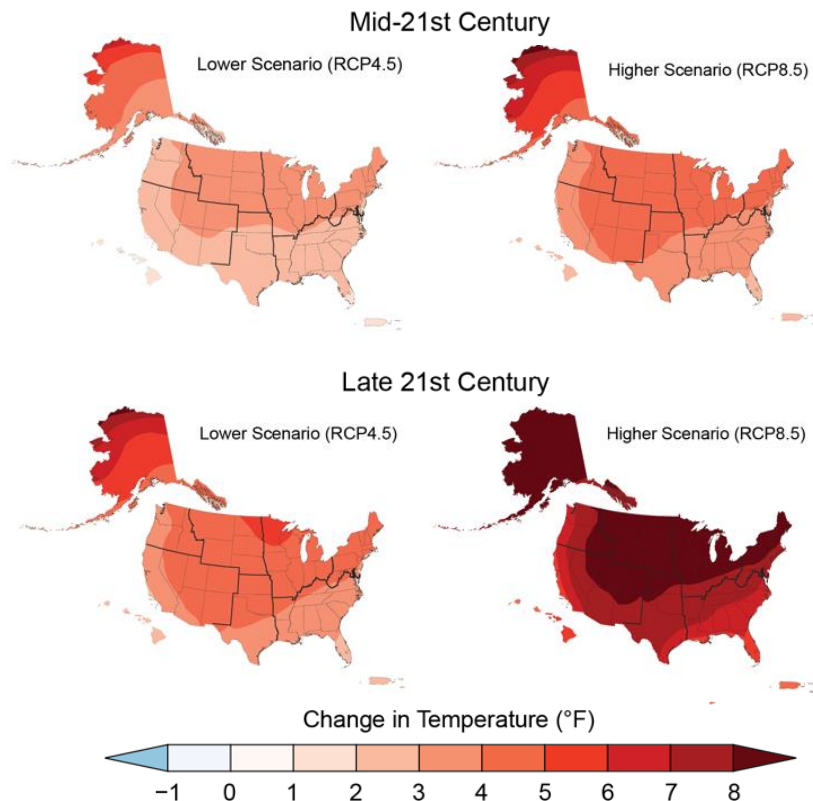
Attribution of Change



Climate will Continue to Change: NCA4 future projections primarily based on widely-used RCP scenarios



Projected Change: *Temperature & Precipitation*

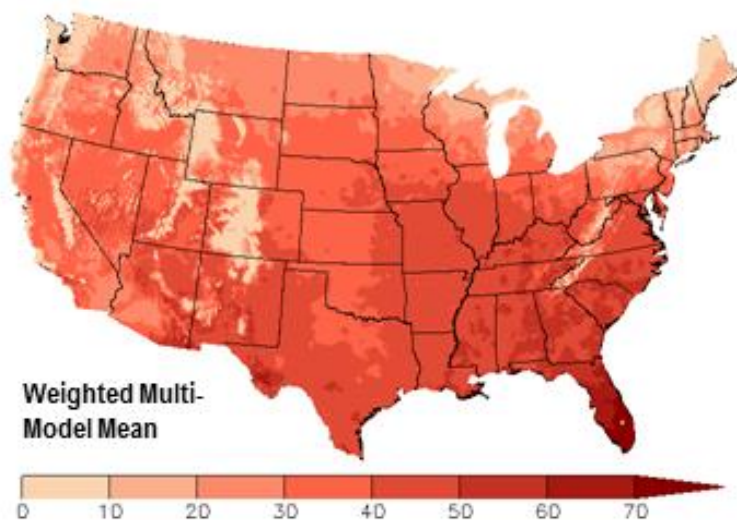


Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where changes are small and relatively insignificant.

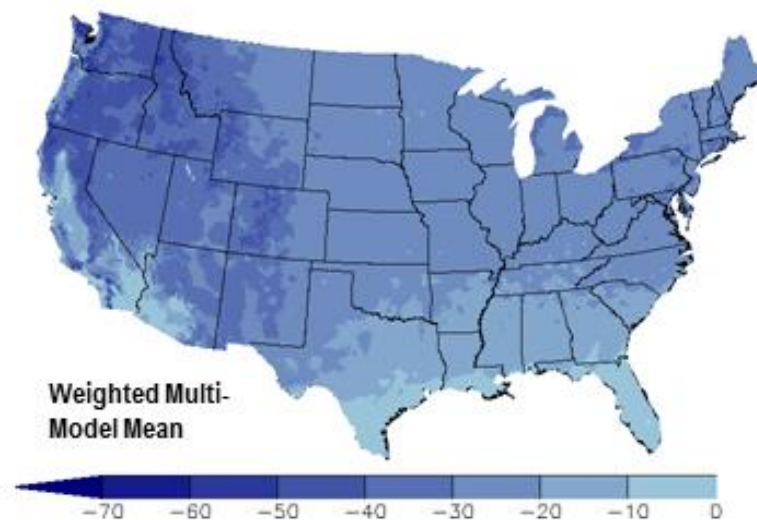


Projected Changes in Number of Days $>90^{\circ}\text{F}$ and $<32^{\circ}\text{F}$ for 2036-2065 relative to 1976-2005 for a High Emissions Scenario

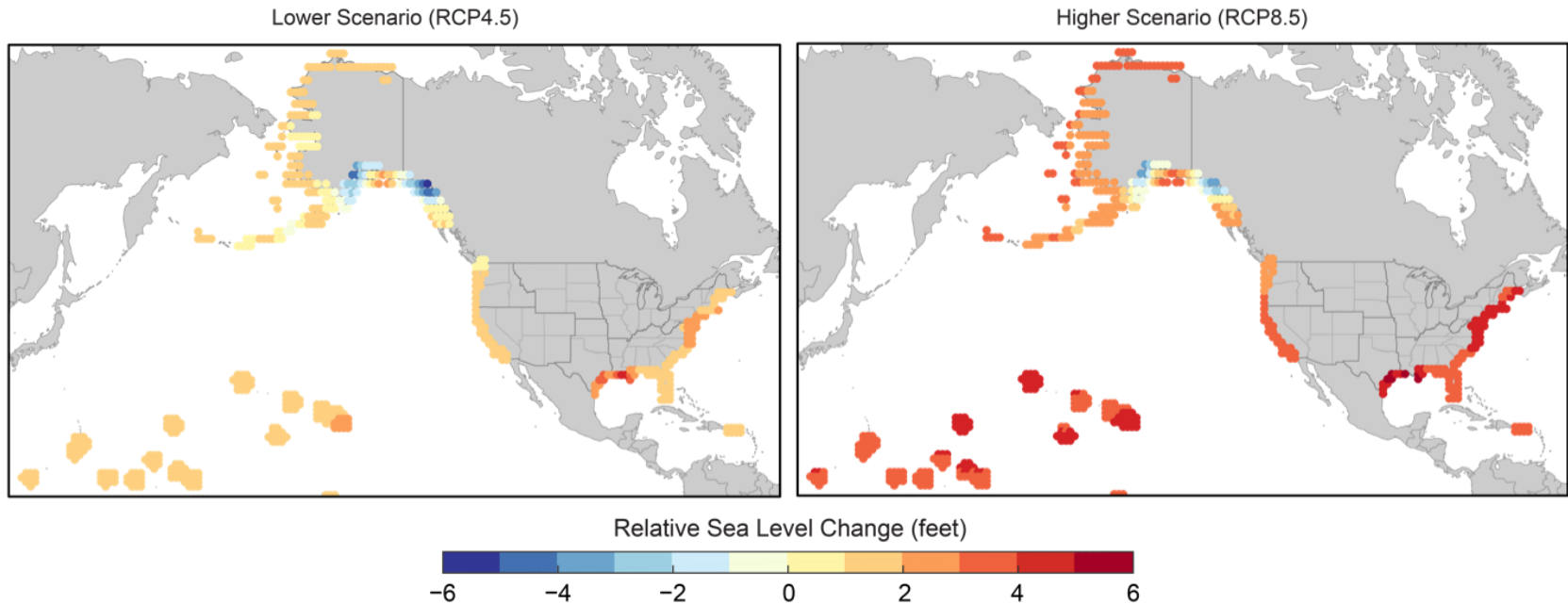
Projected Change in Number of Days Above 90°F
Mid-21st Century, Higher Emissions



Project Change in Number of Days Below 32°F
Mid-21st Century, Higher Emissions



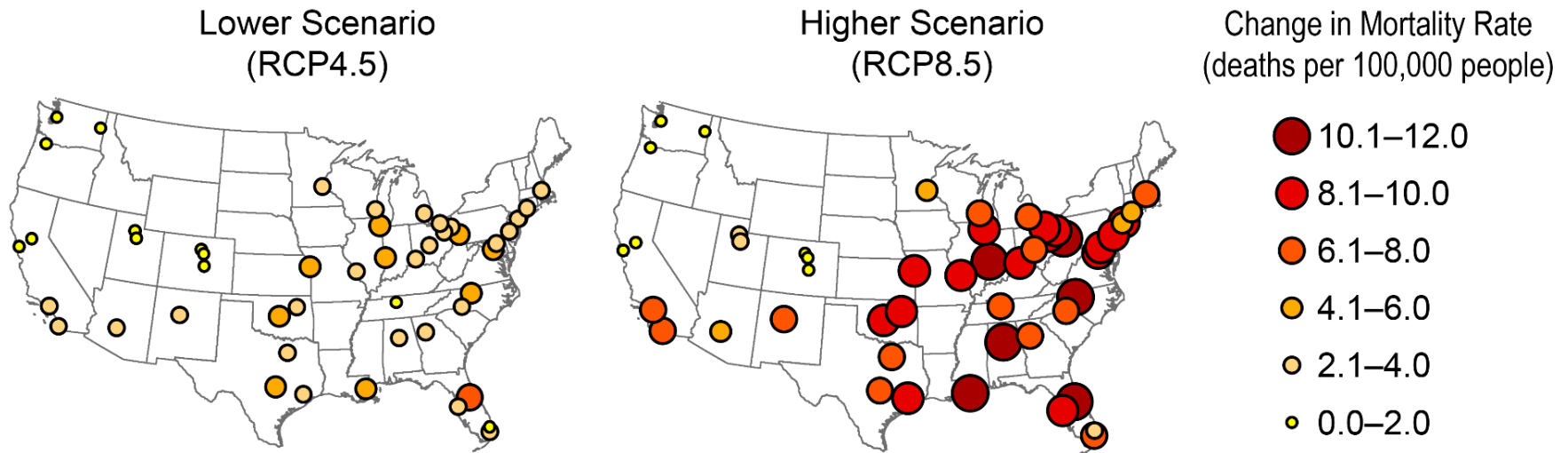
Sea Level Rise (in 2100 vs. 2000)



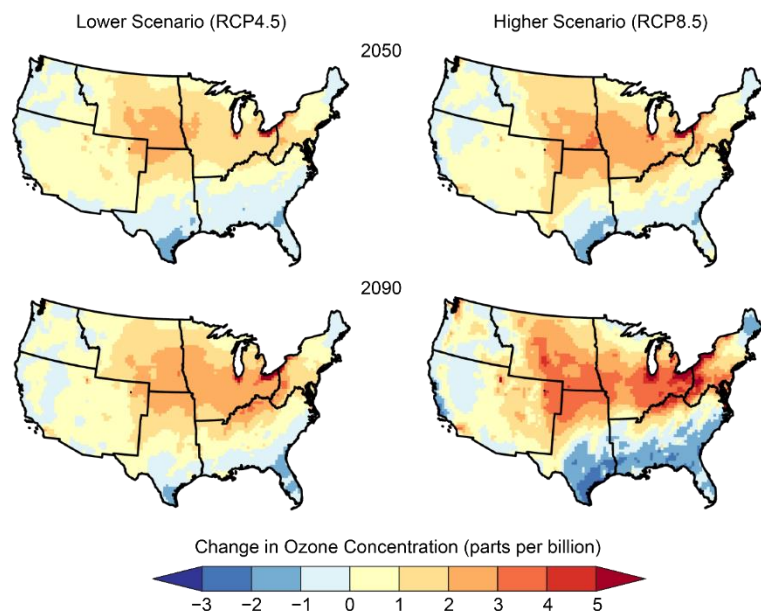
Thermal Expansion + Land-Based Ice Melt + Vertical Land Movement + Ocean Circulation...



Human health: increases in heat-related deaths projected to outweigh reductions in cold-related deaths



Air quality: climate impacts on ozone



- Nationally, ozone concentrations have been reduced by 22% over the 1990 to 2016 period
- Nonetheless, in 2015 nearly 1 in 3 Americans were exposed to ozone values that exceeded the national standard determined by EPA to be protective of human health
- There is high confidence that climate change will increase ozone levels over much of the United States, particularly over already polluted areas
- This climate penalty will partially counteract the continued reductions in emissions of ozone precursors from human activities



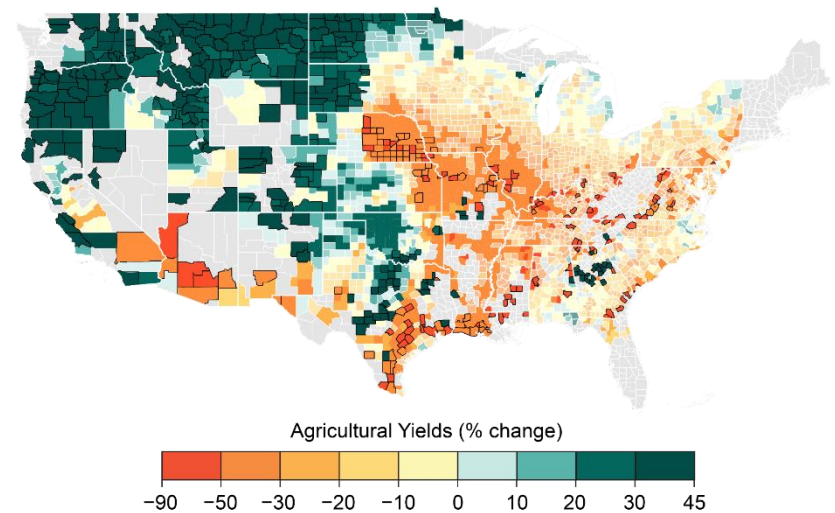
Air quality: climate impacts on particulate matter?

- PM_{2.5} accounts for most of the health impacts due to air pollution in the United States
- Without consideration of climate effects, concentrations of PM_{2.5} in the United States are projected to decline through 2040 due to ongoing emissions control efforts
- PM_{2.5} is highly sensitive to weather conditions
- Accordingly, the net impact of climate-driven weather changes on PM_{2.5} concentrations is less certain than for ozone.

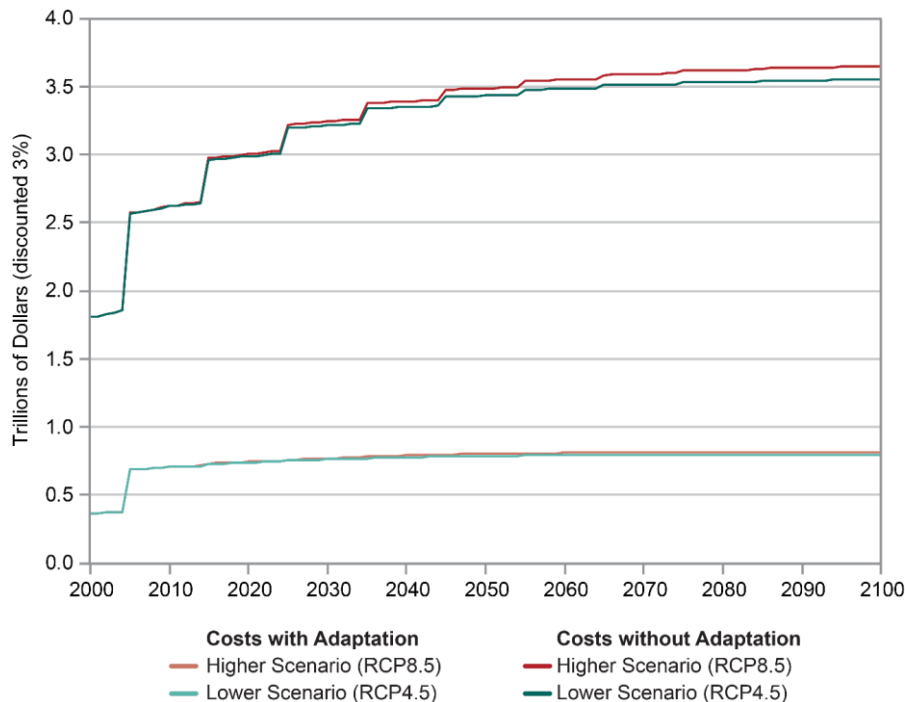


Food production: risks are highly regional, as is ability of producers to adapt

- Any change in the climate poses a major challenge to agriculture
- Important for rural communities
- Producers have options to adapt
- Extended growing season can have positive effects, but net effect of changing climate is multifaceted



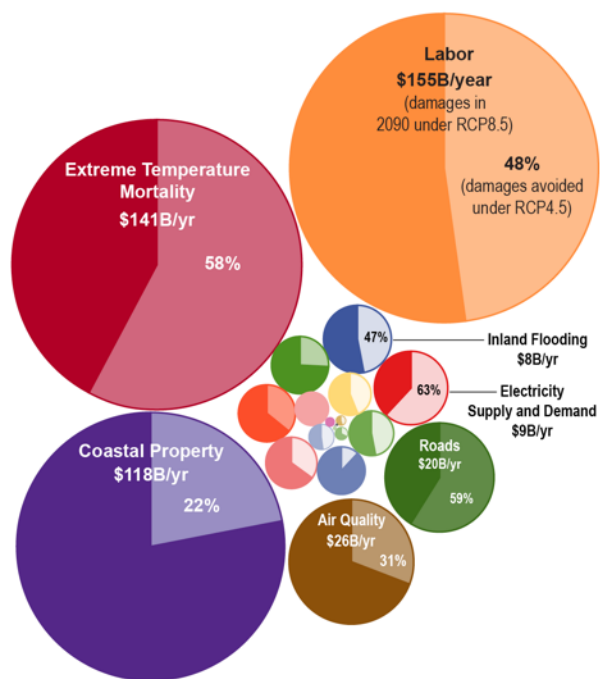
Coastal effects: sea-level rise is amplifying impacts from storm surge and high tides



- As of 2013, coastal shoreline counties were home to 133.2 million people, or 42% of the population
- Threats from SLR are exacerbated by dynamic processes such as high tide and storm surge flooding
- This figure shows that cumulative damages (in 2015 dollars) to coastal property across the contiguous U.S. would be significantly reduced if protective adaptation measures were implemented



Multi-sector analyses of monetary costs, and implications of future scenario



Annual Economic Damages in 2090		
Sector	Annual damages under RCP8.5	Damages avoided under RCP4.5
Labor	\$155B	48%
Extreme Temperature Mortality	\$141B	58%
Coastal Property	\$118B	22%
Air Quality	\$26B	31%
Roads	\$20B	59%
Electricity Supply and Demand	\$9B	63%
Inland Flooding	\$8B	47%
Urban Drainage	\$6B	26%
Rail	\$6B	36%
Water Quality	\$5B	35%
Coral Reefs	\$4B	12%
West Nile Virus	\$3B	47%
Freshwater Fish	\$3B	44%
Winter Recreation	\$2B	107%
Bridges	\$1B	48%
Munic. and Industrial Water Supply	\$316M	33%
Harmful Algal Blooms	\$199M	45%
Alaska Infrastructure	\$174M	53%
Shellfish*	\$23M	57%
Agriculture*	\$12M	11%
Aeroallergens*	\$1M	57%
Wildfire	-\$106M	-134%

- The total area of each circle represents the projected annual economic damages under a higher warming scenario (RCP8.5) in 2090 relative to a no-change scenario.
- The decrease in damages under a lower warming scenario (RCP4.5) compared to RCP8.5 is shown in the lighter-shaded area of each circle.



Northeast: changing seasonality

- The seasonality of the Northeast is central to the region's sense of place and is an important driver of rural economies.
- Less distinct seasons with milder winter and earlier spring conditions are already altering ecosystems and environments in ways that adversely impact tourism, farming, and forestry.
- The region's rural industries and livelihoods are at risk from further changes to forests, wildlife, snowpack, and streamflow.

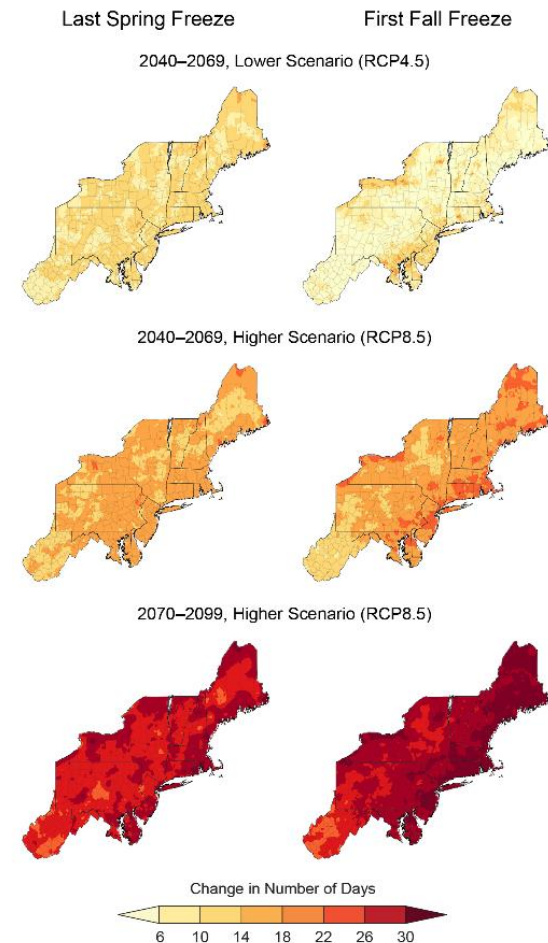
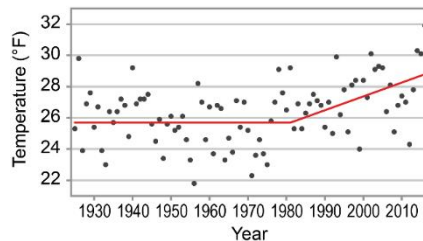


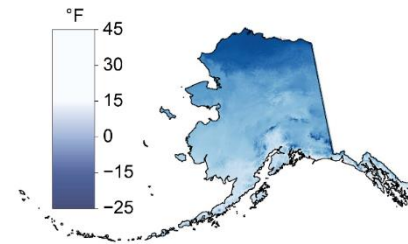
Fig 18.3- Lengthening of the freeze-free period

Alaska: temperature changes, permafrost thaw, indigenous peoples

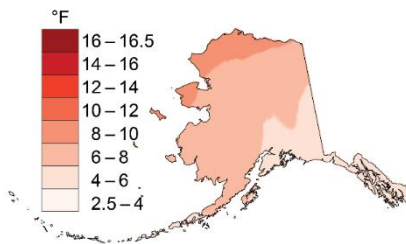
(a) Annual Average Temperature
(1925–2016)



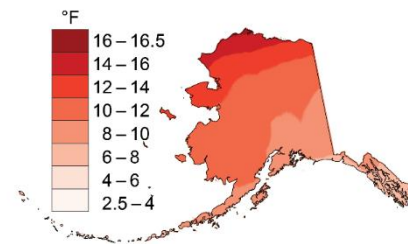
(b) Annual Average Temperature
(1970–1999)



(c) Projected Change in Annual Average Temperature
(RCP4.5, 2070–2099)



(d) Projected Change in Annual Average Temperature
(RCP8.5, 2070–2099)



- Alaska residents, communities, and their infrastructure continue to be affected by permafrost thaw, coastal and river erosion, increasing wildfire, and glacier melt. These changes are expected to continue into the future with increasing temperatures.
- The subsistence activities, culture, health, and infrastructure of Alaska's Indigenous peoples and communities are subject to a variety of impacts, many of which are expected to increase in the future.



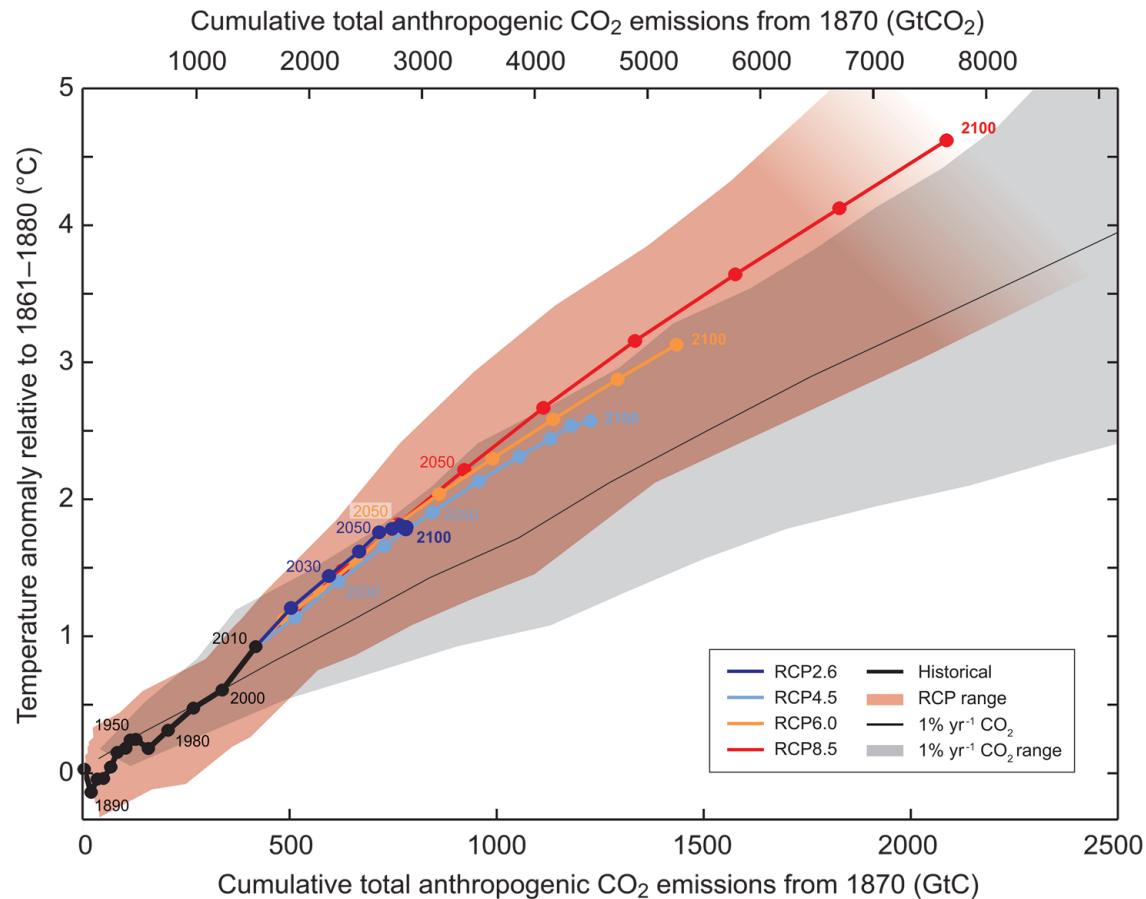
Reducing Risks Through Adaptation Action



- Adaptation is an ongoing, iterative process
- Since NCA3, the scale and scope of adaptation implementation has increased
- It remains difficult to tally the extent of adaptation implementation since there are no common reporting systems, and many actions that reduce climate risk are not labeled as climate adaptation
- Enough is known, however, to conclude that adaptation implementation is neither uniform nor commonplace across the U.S.



Nearly linear relationship between cumulative CO₂ emissions and global mean temperature increases



Source:
IPCC
2013

THANK YOU!

Ben DeAngelo
ben.deangelo@noaa.gov

*Thank you to the hundreds of volunteer
federal and non-federal authors, editors, and
technical contributors to NCA4*

Connect with us:



@usgcrp



usgcrp



GlobalChange.gov

nca2018.globalchange.gov



U.S. Global Change
Research Program